2853
#9

PATENT
3782-0118P

11-16-01

IN THE U. S. PATENT AND TRADEMARK OFFICE

APPLICANTS:	Petter ERICSON et al.	CONF. NO.	1164
APPLN. NO.:	09/812,905	GROUP:	2853
FILED:	March 21, 2001	EXAMINER:	Unknown
FOR:	SYSTEMS AND METHODS FOR PRINTING BY USING A POSITION-CODING PATTERN		

LETTER SUBMITTING TRANSLATION
OF NON-ENGLISH LANGUAGE PROVISIONAL APPLICATION
PURSUANT TO 35 U.S.C. § 119(e) AND 37 C.F.R. 1.78(a)(5)

Assistant Commissioner for Patents
Washington, D.C. 20231

September 28, 2001

Sir:

In accordance with the requirements of 35 U.S.C. § 119(e) and 37 C.F.R. § 1.78(a)(5), attached hereto is a verified English language translation of U.S. Provisional Application No. 60/210,651 filed on June 9, 2000. This submission completes the claim for priority of this provisional application in the above-identified patent application.

If necessary, the Commissioner of hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under § 1.17; particularly, extension of time fees.

Respectfully submitted,
BIRCH, STEWART, KOLASCH & BIRCH, LLP

By: _____
Michael K. Mutter
Reg. No. 29,680

MKM/gf
(703) 205-8000

P.O. Box 747
Falls Church, VA 22040-0747

VERIFIED TRANSLATION

I, the undersigned Margareta Backen, technical translator, of Bellevuevägen 46, S-217 72 MALMÖ, Sweden, do hereby declare:

(1) That I am well familiar with the Swedish and English languages;

(2) That the attached is a true and accurate translation into the English language of the Swedish text of this Patent Application entitled "Printer" that was filed in the US Patent and Trademark Office on 9 June 2000.

(3) That all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both under § 1001 of title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: this 18th day of January 2001

Margareta Backen

AP 0021

3782-118P

UNITED STATES PATENT APPLICATION

OF

PETTER ERICSON

FOR

PRINTER

Field of the Invention

The present invention relates to a printer for dispensing dye on a surface.

Background of the Invention

The use of computers continuously increases in society. Computers have significantly facilitated the processing of information. Although computers can present information on displays, there is a need for printing information on paper. Generally computers are connected to a printer in a network.

The use of portable computers increases more and more. To benefit maximally by the fact that they are portable, they must be connected to a portable printer. There are a large number of printers on the market which operate according to a number of different principles. Essentially two kinds of printer are presently used, viz. laser printers and inkjet printers. Laser printers are based on parts of a sheet of paper being charged with static electricity. On the charged parts of the sheet, toner is applied which adheres owing to the static electricity. Then the toner is made to stick to the sheet by burning. Inkjet printers operate in such manner that the sheet of paper is made to pass an inkjet head which is adapted to move back and forth perpendicular to the plane of the sheet. The inkjet head sprays ink according to a pattern which is stored in digital form. A common feature

of both types of printer is that they are relatively bulky and thus inconvenient to carry along.

There is thus a need for a new kind of compact printer which can easily be carried by a user.

Summary of the Invention

An object of the present invention is to provide a small and compact printer.

A further object of the present invention is to provide a printer which need not be in contact with the edges of the base on which printing is carried out.

One more object of the present invention is to provide a printer which can be used to print on the surface of a base of arbitrary shape.

Another object of the present invention is to provide a method for printing information on the surface of a base of arbitrary shape.

A basic concept of the present invention is to use information on the surface of the base, on which surface information is to be printed, to decide whether dye is to be dispensed.

A printer according to the invention comprises a nozzle for dispensing dye on a surface. The printer is characterized in that it further comprises an image sensor for recording an image of the surface, the printer being adapted to dispense the dye on the surface with the aid of the recorded image.

By dispensing is here meant that the dye is dispensed from the nozzle.

According to an embodiment of the invention, the nozzle is a conventional inkjet head.

The dye is preferably dissolved in a liquid, but within the scope of the invention the dye can also be pulverulent.

Preferably the dye is ordinary ink, but it can also be some other suitable dye.

By the printer being adapted to record an image of the surface and dispensing the dye with the aid of information in the recorded image, the printer need not detect the outer edges of the sheet of paper, which is the case in conventional printers which make use of direct or indirect knowledge of the location of the sheet in the printing operation. This means that the printer can be made extremely small.

Preferably, the printer also comprises a memory for storing graphic information in the form of a plurality of graphics positions.

By graphic information is here meant images or text that can be printed on a surface.

According to a less preferred embodiment, the printer communicates with an exterior memory containing the graphic information.

The printer is advantageously adapted to convert text and images that are to be printed, into said plu-

rality of graphics positions. As a result, information that is to be printed using the printer can be entered as text. It is graphic information that is printed using the printer.

The printer is advantageously adapted to convert the recorded image into at least one recorded position in the form of two coordinates, in response to the recorded image containing a position-coding pattern which codes at least one position.

By adapting the printer to determine a recorded position starting from a position-coding pattern, it can easily determine its position. When moving the nozzle and the image sensor over the surface, an image corresponding to the graphic information will thus gradually develop.

According to a less preferred embodiment, the printer can determine relative movements by comparing different images with each other. With the aid of recorded images, the printer can decide how much it has been moved by putting together recorded images and thus dispensing the dye so that the graphic information is printed. However, this is considerably more complicated.

The printer is advantageously adapted to transform the graphics positions in the graphic information in response to an input signal containing information about how the graphics positions are to be transformed.

The graphics positions can then be printed on a base with a position-coding pattern which codes arbitrary

positions by the graphics positions being transformed to graphics positions which conform with positions coded by the position-coding pattern.

The transformation is preferably carried out with the aid of said at least one recorded position as input signal, so that one of the graphics positions essentially conforms with a position in the position-coding pattern.

This means that a printer automatically transforms the graphics positions with the aid of the position-coding pattern. For instance, the graphics positions are transformed so that the median of the different graphics positions will be in the recorded position which is recorded first.

The printer is preferably adapted to determine a predicted position of the nozzle by means of the recorded position and to dispense the dye when the predicted position conforms with a graphics position in the graphic information.

The predicted position is a position in which the nozzle is expected to be located on a subsequent occasion when the dye is being dispensed. Owing to the fact that it takes time to process a recorded image and since it takes a certain time from a signal being emitted that the dye is to be dispensed until the dye is actually dispensed, the predicted position is not the same as the recorded one.

When the recorded position is the correct position the dye is thus dispensed. By moving the nozzle and the image sensor over all positions on the surface of a base, all the graphic information is printed, provided that the position-coding pattern codes all graphics positions in the graphic information.

According to a less preferred embodiment, the printer is adapted to dispense the dye on the surface when the recorded position conforms with a graphics position in the graphic information. This requires that the image-processing be quick or that the printer be moved slowly. If the dye is dispensed without a predicted position being calculated, the possible resolution of the printed image is deteriorated since a certain displacement will arise between the graphics position and the position in which the dye is dispensed. The displacement depends on the image-processing speed and the speed of the nozzle.

The position-coding pattern is advantageously arranged as a plurality of symbols in a matrix, each symbol defining a binary digit for each of two directions. A part of a predetermined size of the matrix unambiguously defines a coordinate.

The printer is preferably adapted to identify a predetermined number of symbols in the recorded image, to separate the position-coding pattern in the image into a first position code for a first coordinate and a second

position code for a second coordinate by translating each symbol into at least one digit for the first position code and at least one digit for the second position code, and to calculate the first coordinate by means of the first position code and the second coordinate by means of the second position code.

Preferably, the nozzle is arranged adjacent to the image sensor at one end of the printer. A recorded position determined by means of the image sensor then conforms with the position of the nozzle.

The printer is preferably adapted to determine the speed and direction of the nozzle in relation to the surface by means of at least two recorded positions converted from at least two recorded images. This makes it possible to take the movement of the nozzle into consideration when dispensing the dye.

The printer is advantageously adapted to calculate the predicted position starting from the last recorded position and the speed and direction of the nozzle.

The printer is preferably handheld although it is within the scope of the invention that the printer is not handheld. The great advantage of the invention is, however, that it is possible to make the printer extremely small and advantageously handheld. In the case where the printer is not handheld, the nozzle and the image sensor are movably arranged in relation to a stationary part of the printer.

The image sensor has advantageously a main viewing direction in which it is adapted to collect radiation from the surface, the printer being adapted to determine its turning position in relation to the viewing direction by means of the recorded image and to dispense the dye with the aid of the turning position.

By the printer determining its turning position, it will be possible to take into account the fact that the nozzle is not centered in relation to the image sensor.

According to a preferred embodiment of the invention, the image sensor thus records an image taken in a direction relative to the image sensor.

According to an embodiment of the invention, the nozzle is adapted to dispense the dye in a plurality of points at the same time. As a result, the printing speed increases.

According to one aspect, the invention provides a system for printing graphic information, comprising a printer and a base. The system is characterized in that the base has a position-coding pattern which codes the absolute coordinates for a plurality of positions on the base, and the printer comprises a nozzle for dispensing dye on the base, and further comprises an image sensor for recording an image of the base, the printer being adapted to dispense the dye on the base with the aid of

the position-coding pattern in the recorded image and the graphic information.

According to one aspect, the invention provides a method for printing stored graphic information on a surface. The method is characterized by the steps of recording an image of a surface, and dispensing the dye on the surface with the aid of the recorded image and the stored graphic information.

According to one aspect, the invention provides a printer which comprises a heating means for heating a base in order to change its color. The printer according to this aspect of the invention is characterized in that it further comprises an image sensor for recording an image of the surface, the printer being adapted to heat the base, so that its color changes, with the aid of the recorded image.

According to this aspect of the invention, the heating step preferably consists of a spark gap. When a spark is generated in the spark gap, the sheet of paper is heated locally at the spark gap. The sheet is heated in points corresponding to graphic information that is to be printed.

The above features can, of course, be combined in the same embodiment.

In order to further illustrate the invention, detailed embodiments of the invention will be described

below, without however the invention being considered to be restricted thereto.

The accompanying drawings are only schematic and, thus, certain dimensions are greatly exaggerated for the purpose of elucidating the invention.

Brief Description of the Drawings

Fig. 1 illustrates a printer according to a preferred embodiment of the present invention.

Fig. 2 illustrates a sheet of paper with a pattern adapted to the printer according to the present invention.

Fig. 3 shows an example of a symbol which can be used in connection with a printer according to the invention.

Fig. 4 shows how a pattern according to the present invention is converted into a recorded position in the form of two coordinates.

Fig. 5 illustrates how an image is composed when using a printer according to the present invention.

Detailed Description of the Invention

Fig. 1 shows a printer according to a preferred embodiment of the present invention. The printer 1 comprises a nozzle in the form of a inkjet head 2 for dispensing ink on a surface, an image sensor 3 in the form of a CCD for recording an image of the surface, and a diode 4 for illuminating the surface. In front of the CCD there is a lens system 8 which is intended for imag-

ing the coding pattern on the CCD. The printer 1 also comprises an image-processing means 5 for processing the image recorded by the image sensor 3, and a battery 6 which constitutes the power supply for the printer. A communication unit 7 is intended for communication between the printer and a computer. The image-processing means 5 consists of a microcomputer and comprises a memory 9 for storage of graphic information. The printer has buttons 10 for operating the printer 1 and a display 11 for presenting information. The information presented on the display is, for instance, the text that is to be printed on the sheet of paper. The printer 1 is adapted to be held by the user's hand and to be passed over a surface which has a position-coding pattern. The printer has a main viewing direction 50 which is the direction in which images are recorded. Since the viewing direction 50 does not extend through the inkjet head, it must be taken into consideration how the pen is turned when ink is being dispensed.

According to an alternative embodiment, the printer has a plurality of nozzles so that ink can be dispensed to a plurality of points simultaneously.

Fig. 2 shows a sheet of paper, which is included in a system according to a preferred embodiment of the present invention and which the printer is adapted to record. The surface of the sheet of paper 12 is provided with a position-coding pattern 13. Fig. 2 is an enlarge-

ment of a small part of the position-coding pattern on the surface of the sheet of paper, which pattern consists of a plurality of symbols arranged in a matrix. In Fig. 2, also the area 16 which is recorded by the printer is marked. The printer can determine a position by means of the recorded image of the position-coding pattern.

The position-coding pattern with which the printer is intended to be used can be of the type disclosed in US 5,852,434, where each position is coded by a specific symbol.

The position-coding pattern is, however, advantageously of the type disclosed in Applicant's Applications SE 9901954-9 and SE 9903541-2, where each position is coded by a plurality of symbols and each symbol contributes to the coding of a plurality of positions.

The position-coding pattern is built up of a small number of types of symbols. An example is disclosed in SE 9901954-9 where a large dot represents a "one" and a small dot represents a "zero". Another example is disclosed in SE 9901954-9, where four different displacements of a dot in relation to a raster point code four different values.

Figs 3a-d show a symbol which can be used for coding positions in the position-coding pattern on the sheet of paper in Fig. 2 according to a preferred embodiment of the invention. The symbol comprises a virtual raster point 14, which is represented by the intersection

between the raster lines, and a mark 15 which has the form of a point. The value of the symbol depends on where the mark is located. In the example in Fig. 3, there are four possible locations, one on each of the raster lines extending from the raster points. The displacement from the raster point is equal to all values. The symbol has in Fig. 3a the value "0", in Fig. 3b the value "1", in Fig. 3c the value "2" and in Fig. 3d the value "3". In other words, there are four different types of symbols. Each symbol can thus represent one of four different values "0-3".

Fig. 4 illustrates the appearance of a sequence 17 which is used in the position-coding pattern according to a preferred embodiment of the invention. The sequence 17 comprises 512 values 18 each of which is either "0", "1", "2" or "3". An arbitrary subsequence 19, 20 with 5 values unambiguously defines a sequence value corresponding to the position of the subsequence in the sequence 17. Each subsequence occurs in the sequence only once. Thus the first subsequence 19 corresponds to the value "0" and the second subsequence 20 to the value "1". In Fig. 2, the columns and rows in the matrix consist of sequences in which the values have been converted into symbols. Sequences of this kind are described in "Pseudo-Random Sequences and Arrays" by F. Jessie MacWilliams and Neil J.A. Sloane in "Proceedings of the IEEE" Vol. 64, No. 12, December 1976.

Fig. 5 shows a part of the position-coding pattern which is reproduced on the sheet of paper 12 in Fig. 2. A first matrix 30 in Fig. 5a is the smallest matrix which unambiguously defines a position. The position-coding pattern 13 is made up of symbols 31 like those shown in Fig. 3. In the position-coding pattern, use is made of the four different values to code a binary bit in each of two orthogonal directions. Thus, the four different values "0, 1, 2, 3" code the four different bit combinations (0, 0), (0, 1), (1, 0), (1, 1), where the first digit in each bit combination relates to a first direction and a second digit relates to a second direction which is orthogonal to the first direction. When the printer records the first matrix 30 in Fig. 3, it is converted to a second matrix 32 with values 33, which defines the x coordinate, and to a third matrix 34 with values 35, which defines the y coordinate, by means of the above-mentioned relationship between values and bit combinations. The second matrix 32 contains subsequences 36 which constitute columns in the second matrix. The values in the matrix are either "0" or "1". The subsequences are a part of the sequence which has been described above in connection with Fig. 3. Each subsequence thus has a unique sequence value. The five subsequences in the columns in the second matrix 32 are converted to five sequence values Sx_1, Sx_2, Sx_3, Sx_4 and Sx_5 which define the x coordinate. Similarly, sub-

sequences 37 with values 35 are arranged in rows in the third matrix. These subsequences are also parts of the sequence in Fig. 4 and are similarly converted to a second set Sy_1-Sy_5 which defines the position of the different subsequences in the sequence. Subsequently the difference between adjacent sequence values is calculated, which gives rise to two sets of four difference values Dx_1-Dx_4 and Dy_1-Dy_4, respectively, $Dx_n=Sx_{n+1}-Sx_n$ modulo R and $Dy_n=Sy_{n+1}-Sy_n$ modulo R, where R is the number of unique subsequences in the sequence in Fig. 4. Then the difference values are used to generate an x coordinate and a y coordinate.

The conversion from difference values to coordinates can be carried out in many different ways. According to one embodiment, the subsequences are arranged in such manner that one of the difference values in each matrix which unambiguously defines a position has an integer value in the range "0-3". This codes the most significant digit. The subsequences are also arranged so that the x coordinate will be one unit greater when moving one column in the matrix and so that the y coordinate will be one unit greater when moving one row in the matrix. Since the columns in the second matrix in Fig. 5b consist of parts of the sequence in Fig. 4, each of the sequence values in the two columns Sx_1 and Sx_2 furthest to the left in the matrix in Fig. 5b will be one unit greater when moving down one row in the matrix 32. However, Dx_1

remains constant. Consequently, also the x coordinate remains constant when moving downwards in the second matrix 32.

Fig. 6 illustrates how a printout is built up as the printer operates. The printer records images of the base and converts them into positions as described above in connection with Fig. 5. As the printer is being passed over the sheet of paper, images of the position-coding pattern are continuously recorded and converted into positions. In Fig. 6a, a first position 40 and a second position 41 are marked. The image-processing means is adapted to calculate a predicted position 42 by means of the first position 40 and the second position 41, by also the interval between the recording of the two images being known. The predicted position 42 is compared with graphics positions which are stored in the memory 9. Since the predicted position 42 conforms with a graphics position which is stored in the memory, ink is dispensed from the inkjet head 2. In the same manner, dispensing of ink from the inkjet head is initiated at all other times when conformity is obtained between the predicted position and a graphics position. The interval between the time of the recording of the image which corresponds to the second position and the time when the inkjet head is in the predicted position is used by the printer to convert the recorded image into a position, to calculate a predicted position, to compare the predicted position 42

with the graphic information and to dispense ink. When the predicted position is calculated, the speed and direction of the printer are thus taken into consideration. As the printer is being passed over the surface, the entire image will thus be built up. This is illustrated in Figs 6a-6d. Since the inkjet head is not centered relative to the image sensor in the printer which is shown in Fig. 1, it is necessary to determine how the printer is turned for ink to be dispensed in the correct position. This is carried out by the image-processing means with the aid of the recorded image.

The graphic information thus consists, as mentioned above, of a number of graphics positions corresponding to the image which is to be printed. Each point corresponds to a minimum point which is printed with the inkjet head. The graphic information corresponds to an image or text which is to be printed. The graphics positions which define the graphic information can be in an arbitrary position. The only relevant matter is that their mutual location is such that they define the graphic information. The position-coding pattern possibly codes positions within a completely different area than that in which the graphics positions are located.

Fig. 7 illustrates how it is taken into consideration that the position-coding pattern codes other positions than those present in the graphic information. When a user initiates that the graphic information is to be

printed, a first image of a position-coding pattern is recorded on a sheet of paper 44, which image is converted into a start position 43. The start position 43 defines where a user wants the graphic information to be printed. The graphic information 45 consists of graphics positions which define an "A". The graphics positions have no positions in common with the position-coding pattern on the sheet of paper 44. The graphics positions are transformed so that a median graphics position 46 will be located in the start position 43. As the printer is then being passed over the sheet of paper, the graphic information is printed in the form of an "A" 47.

According to an alternative embodiment, use is made of the property that the graphics positions do not coincide with the position-coding pattern. It is then necessary to have access to a sheet of paper with a position-coding pattern which codes precisely the graphics positions which are present in the graphic information to allow it to be printed. The graphic information can be, for example, handwritten text recorded by means of another position-coding pattern than the one used in the printing of the information.

The conversion of text or images can be carried out in a number of ways which can easily be accomplished by a person skilled in the art and will therefore not be described in detail.

The embodiments described above are to be considered as examples only.

A person skilled in the art appreciates that the above embodiments can be varied in many ways without departing from the inventive concept. For instance, it is possible to use some other type of symbols in the position-coding pattern. Different values can, for instance, be coded with filled circles of different size.

What I claim and desire to secure by Letters Patent is:

1. A printer comprising a nozzle (2) for dispensing dye on a surface, c h a r a c t e r i z e d in that it further comprises an image sensor (3) for recording an image of the surface, the printer (1) being adapted to dispense the dye on the surface with the aid of the recorded image and graphic information that is to be printed.

2. A printer as claimed in claim 1, c h a r a c - t e r i z e d in that it further comprises a memory (9) for storing the graphic information in the form of a plurality of graphics positions.

3. A printer as claimed in claim 2, c h a r a c - t e r i z e d in that it is adapted to convert text and images, which are received by the printer to be printed, into said plurality of graphics positions.

4. A printer as claimed in claim 2 or 3, c h a r - a c t e r i z e d in that it is adapted to convert the recorded image into at least one recorded position in the form of two coordinates, in response to the recorded image containing a position-coding pattern (13) coding at least one position.

5. A printer as claimed in claim 4, c h a r a c - t e r i z e d in that it is adapted to transform the graphics positions in the graphic information in response to an input signal containing information about a transformation.

6. A printer as claimed in claim 5, c h a r a c - t e r i z e d in that the transformation is carried out with the aid of said at least one recorded position as the input signal, so that one of the graphics positions essentially conforms with a position in the position-coding pattern.

7. A printer as claimed in any one of claims 4-6, c h a r a c t e r i z e d in that it is adapted to dispense the dye on the surface when the recorded position conforms with a graphics position in the graphic information.

8. A printer as claimed in any one of claims 4-6, c h a r a c t e r i z e d in that it is adapted to determine a predicted position of the nozzle (2) by means of the recorded position, and to dispense the dye when the predicted position conforms with a graphics position in the graphic information.

9. A printer as claimed in claim 8, c h a r a c - t e r i z e d in that the printer is adapted

to determine the speed and direction of the nozzle (2) in relation to the surface by means of at least two recorded positions converted from at least two recorded images, and

to calculate the predicted position starting from one of the recorded positions as well as the speed and direction of the nozzle (2).

10. A printer as claimed in any one of claims 4-8, c h a r a c t e r i z e d in that it is adapted to determine the speed and direction of the nozzle (2) in relation to the surface by means of at least two recorded positions converted from at least two recorded images.

11. A printer as claimed in any one of claims 4-10, c h a r a c t e r i z e d in that it is adapted

to identify a predetermined number of symbols (15, 31) in the position-coding pattern (30) in the recorded image, and

to separate the position-coding pattern (30) in the image into a first position code (32) for a first coordinate and a second position code (34) for a second coordinate by translating each symbol into at least one digit for the first position code and at least one digit for the second position code, and

to calculate the first coordinate by means of the first position code and the second coordinate by means of the second position code.

12. A printer as claimed in any one of the preceding claims, c h a r a c t e r i z e d in that it is handheld.

13. A printer as claimed in any one of the preceding claims, c h a r a c t e r i z e d in that the image sensor (3) has a main viewing direction (50) in which it is adapted to record radiation from the surface, the printer being adapted to determine its turning position in relation to the viewing direction (50) by means of the

(continued)

(continued claim 13)

recorded image, and to dispense the dye with the aid of the turning position.

14. A printer as claimed in any one of the preceding claims, c h a r a c t e r i z e d in that the nozzle (2) is adapted to dispense dye in a plurality of directions.

15. A system for printing graphic information, comprising a printer (1) and a base (12), c h a r a c t e r i z e d in that

the base (12) has a position-coding pattern (13, 30) which is designed so that an arbitrary subset of the position-coding pattern (13, 30), said subset having a predetermined size, codes the absolute coordinates for a position on the base (12), and

the printer (1) comprises a nozzle (12) for dispensing dye on a base (12), and further comprises an image sensor (3) for recording an image of the base (12), the printer (1) being adapted to dispense the dye on the base (12) with the aid of the position-coding pattern in the recorded image (16) and the graphic information.

16. A method for printing stored graphic information on a surface, c h a r a c t e r i z e d by the steps of

recording an image of a surface, and

dispensing the dye on the surface with the aid of the recorded image and the stored graphic information.

Abstract of the Disclosure

A printer (1) comprises a nozzle (2) for dispensing dye on a surface. The printer (1) also comprises an image sensor (3) for recording an image (16) of the surface, the printer (1) being adapted to dispense the dye on the surface with the aid of the information in the recorded image (16).

Elected for publication: Fig. 6

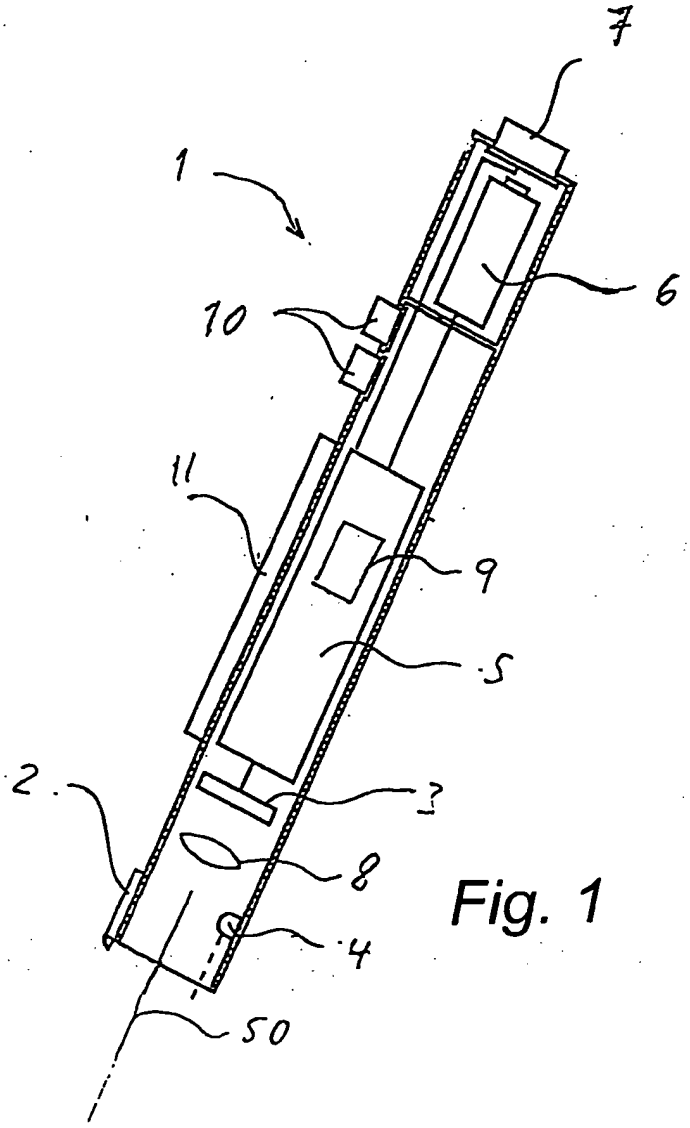

Fig. 1

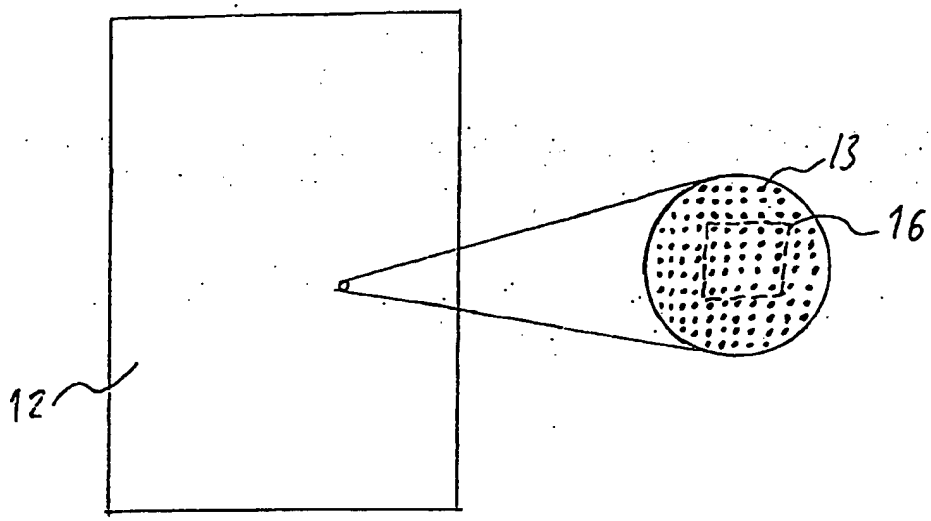

Fig. 2

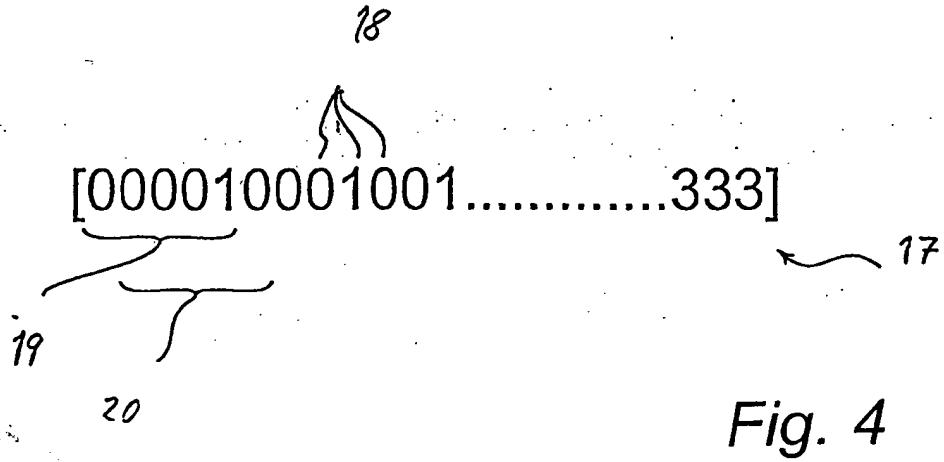

Fig. 4

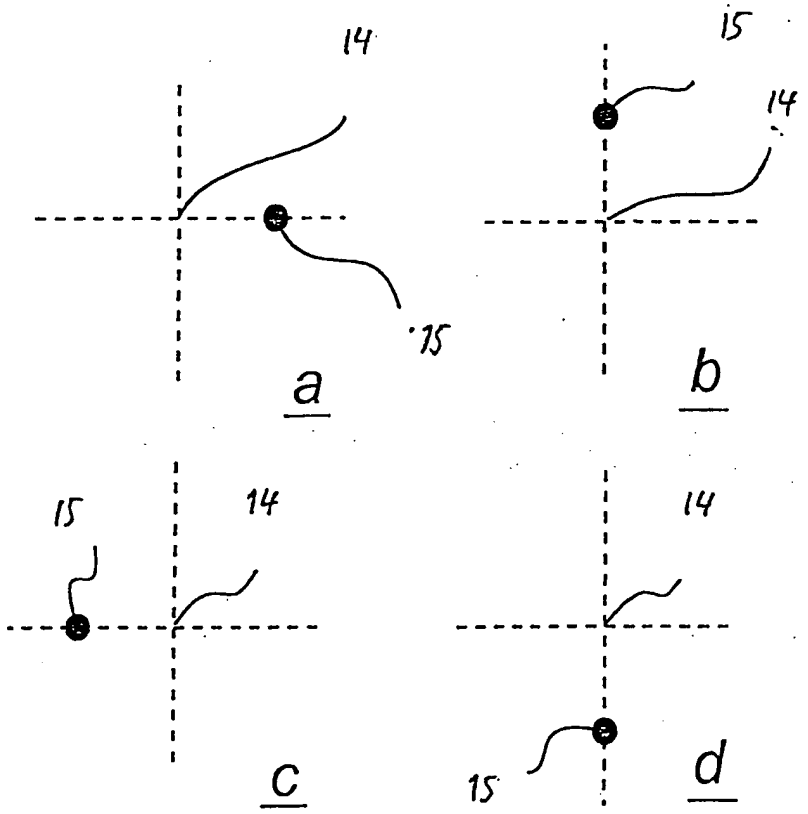

Fig. 3

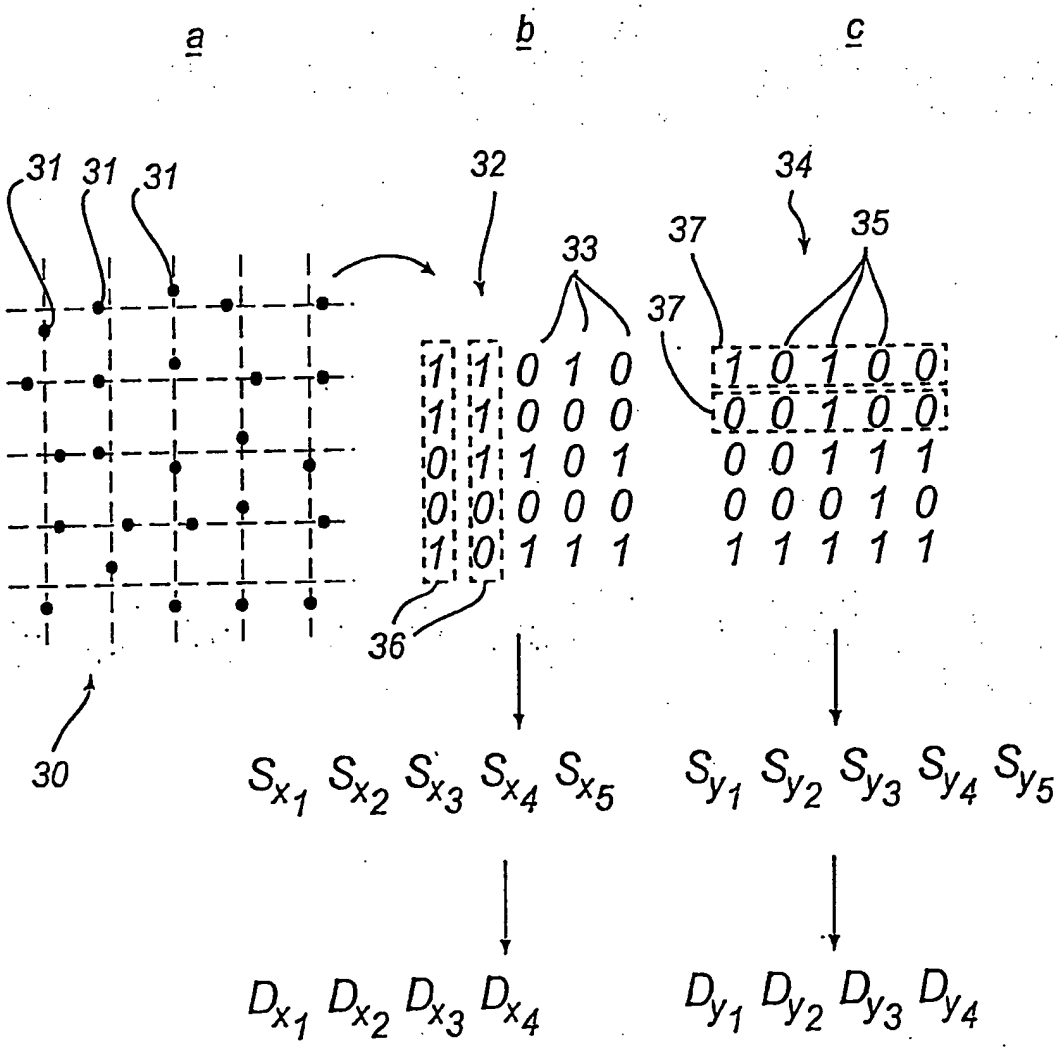
a
b
c
31
31
31
32
33
34
35
37
37
1 1 0 1 0
1 1 0 0 0
0 1 1 0 1
0 0 0 0 0
1 0 1 1 1
1 0 1 0 0
0 0 1 0 0
0 0 1 1 1
0 0 0 1 0
1 1 1 1 1
36
30
S_{x_1} S_{x_2} S_{x_3} S_{x_4} S_{x_5}
S_{y_1} S_{y_2} S_{y_3} S_{y_4} S_{y_5}
D_{x_1} D_{x_2} D_{x_3} D_{x_4}
D_{y_1} D_{y_2} D_{y_3} D_{y_4}

Fig. 5

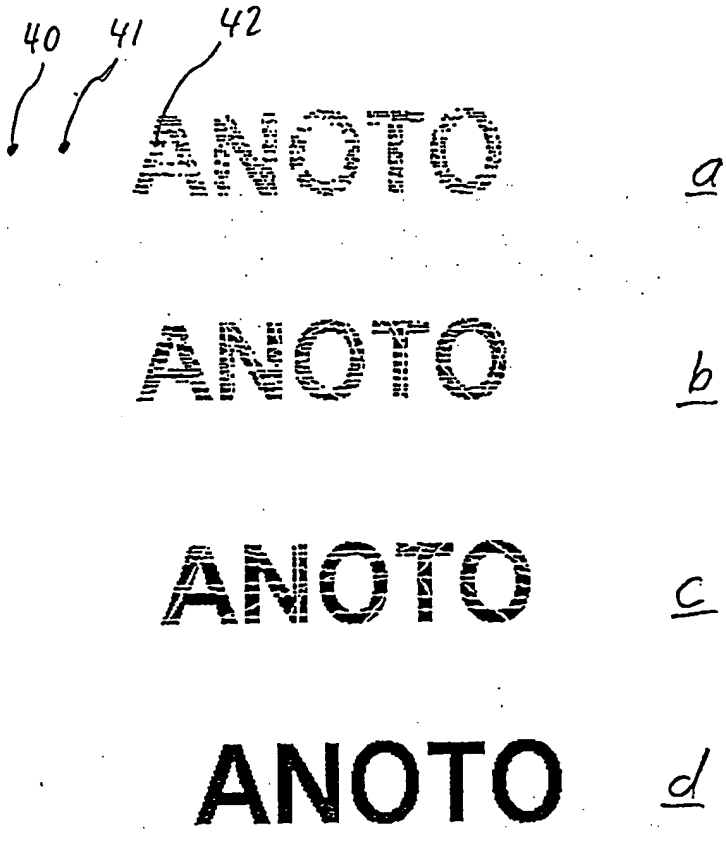

Fig. 6

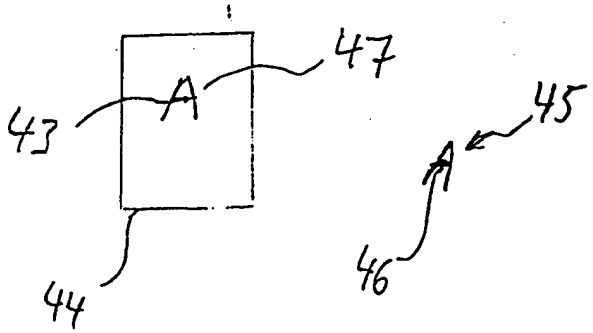

Fig. 7